Determinants and persistence of research and development investments

Evidence from Malaysia

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Abstract

Purpose – The purpose of this paper is to investigate the determinants and persistence of research and development (R&D) investments in Malaysia.

Design/methodology/approach – The approach involves a regression analysis.

Findings – The regression analysis shows that lagged absorbed slack defined as the ratio of selling and administrative expenses to total sales and sales growth have positive affect on the R&D expenses, whereas diversification has negative impact on R&D expenses after controlling for leverage and profitability of the firms. Persistence in the firm-level R&D expenses is found. Occasional tendency among firms to cut down R&D spending over the period of 2000-2005 is found.

Research limitations/implications – Sample size is a limitation.

Practical implications – The findings have implications for the corporate governance and innovation charter of the firms.

Originality/value – The paper provides useful information from Malaysia regarding the determinants and persistence of R&D investments.

Keywords Research and development, Chief executives, Stock options, Malaysia

Paper type Research paper

1. Introduction

The firm-level research projects can be seen as first stage in a sequential process that lead to the creating of new knowledge which transforms into new products or processes by mean of further development in a firm. The patents which are filed during the development stage provide protection to a firm against patent infringement. The patents, in a broader sense, reflect the final result of a firm's research and development (R&D) project (Ernst, 1998) which yields economic benefits such as competitive advantage and high market share.

We operationalize the construct of innovation as technological changes that result from any firm-level innovation activity. There are two types of technological changes that affect a firm's productivity – first, radical improvements which are newly designed plants and operations (Upstill and Hall, 2006) and second, incremental

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improvements which are the improvements in components, machinery, and subsystems (Tidd *et al.*, 2001). Another technological innovation, referred to in the research literature, is the management and process changes to reduce waste, dust, noise, water and air pollution, or damage to flora and fauna. In this paper, we focus only on the first two types of technological changes observed through R&D expenses of the listed firms in Malaysia.

Most of the previous studies have either examined the impact of tax incentives, product market competition (Bloom *et al.*, 2002; Blundell *et al.*, 1999), and public policies (Jaumotte and Pain, 2005a, b) on the firm-level R&D. Our research differs from the previous studies as follows. First, most of the recent studies have examined the impact of interaction between universities and corporate sectors in promoting innovation (Hershberg *et al.*, 2007; Sohn and Kenney, 2007; Wong *et al.*, 2007). We take up the issue of R&D for the first time in the context of Malaysia by using a sample of listed firms. Most of the recent studies have focused on the following countries such as South Korea, Hong Kong, Taiwan (Chen and Huang (2006), and Japan. For instance, Hu and Mathews (2005, p. 1326) report that increases in patenting rates in Taiwan, Korea, Hong Kong, and China are accompanied by an increase in R&D expenditure, and they interpreted this as an increase in innovative activity of these nations. According to their classification (Table I), Taiwan has the largest number of patents per capita of 17.2 and Hong Kong has the lowest number of patents per capita over the period of 1997-2001.

In our analysis using data on R&D at firm-level, we come to conclusion that there has been a greater tendency among firms to cut their R&D spending over the sample period in Malaysia. Second, lagged sales growth and absorbed slack has a significant influence on the R&D expenses. The organization of this paper is as follow: Section 2 briefly discusses the state of R&D in Asia, and more specifically in Malaysia in Section 3. Section 4 describes the sample, variables and model used in analysis of the determinants of R&D spending in Section 5. Section 6 concludes.

2. Research and development in Asia

The international spending on the R&D has increased due to intense cost competition led by globalization, adoption of information, and communication technologies (Upstill and Hall, 2006). According to Global R&D Report (2005) the effects of outsourcing, insourcing, and shifting political landscapes will bolster global R&D efforts. The total global R&D spending is estimated to increase from US$ 922.58 billion in 2004 to US$ 1,023.53 trillion in 2006.

Asia lags behind North America in R&D spending, and its share of total global R&D is estimated to be 39.5 percent of the global R&D even though Asian countries have doubled their investments from US$ 94.2 billion in 1990 to US$ 404.34 billion in 2006 (in purchasing power parities). There are marked differences among the Asian countries in terms of spending on R&D. For instance, Japan and China have 12.4 and 13.6 percent share of total global R&D, respectively. The US Patent and Trade Mark Office report shows that Japan has the highest number of patents (39,411) granted in 2006 followed by Taiwan (10, 889) and South Korea (6,509), respectively. Although at national level, Asian countries are embarking on the strategies to promote innovation as a key to economic success in future but it remains less clear quantitatively what has been the impact of those innovation boosting strategies or measures on the innovation footprint of a country?

Table I. The total number of utility patents defined by US Patent and Trade Mark Office for a sample of countries

Country	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Total
Iran	2	1	1	2	2	–	1	–	1	–	2	–	–	–	1	2	15
Pakistan	–	1	1	1	1	1	–	2	–	5	2	1	–	2	3	2	22
Kuwait	1	1	2	1	1	2	2	1	10	8	6	8	7	4	3	7	64
Indonesia	2	8	4	9	4	1	5	3	5	6	4	7	9	4	10	3	84
Philippines	5	7	4	1	4	4	4	8	11	2	12	14	22	21	18	35	172
Saudi Arabia	5	8	3	11	10	12	14	14	12	19	12	10	19	15	18	19	201
Thailand	2	1	5	5	8	11	5	13	20	15	24	44	25	18	16	31	243
Malaysia	12	5	13	10	7	12	17	23	30	42	39	55	50	80	88	113	596
India	22	24	30	27	37	35	47	85	112	131	178	249	342	363	384	481	2,547
Hong Kong	50	60	60	57	86	88	81	160	155	179	237	233	276	311	283	308	2,624
China	50	41	53	48	62	46	62	72	90	119	195	289	297	404	402	661	2,891
Singapore	15	32	38	51	53	88	94	120	144	218	296	410	427	449	346	412	3,193
South Korea	405	538	779	943	1,161	1,493	1,891	3,259	3,562	3,314	3,538	3,786	3,944	4,428	4,352	5,908	43,301
Taiwan	906	1,001	1,189	1,443	1,620	1,897	2,057	3,100	3,693	4,667	5,371	5,431	5,298	5,938	5,118	6,360	55,089

Source: US Patent and Trade Mark Office

This paper argues that corporate sector has an important role to play in Asian countries due to the following reasons. First, governments in many Asian countries such as Malaysia, are facing development related problems such as provision of basic needs for example, food, housing, infrastructure, and social security, and therefore have limited resources to spend on innovation. Second, government owned corporations have significantly reduced in number across many countries due to privatization. The privatization strategy is aimed to enhance productivity, competition, and promote efficient allocation of capital. Third, governments rely on foreign debt and grants to promote development projects for the social needs of people. Thus, in the light of these reasons, it is reasonable to expect that corporate sector is a torch barrier of innovation in the Asian countries. In a nutshell, a country's innovation can be gauged through R&D expenditure incurred by its corporate sector.

3. Research and development in Malaysia

In the case of Malaysia, national innovation focus has been on the key industries with the support of specific organizations such as The research in priority areas fund to finance research in the emerging fields such as automation, electronics, IT, material, and biotechnology. The industrial technical assistance fund was set up in 1990 to provide financial support to SMEs for the consultancy studies, productivity, quality improvements, and design and product development. Some of other government's initiatives include the Malaysian Technology Development Corporation in 1992, Malaysian industry Government Group for High Technology in 1993, both joint public-private sector initiatives were launched to help commercialize new research and technology.

Malaysian government has also provided unprecedented tax incentives unlike in any other Asian country to "high-technology" companies, defined as those firms who invest at least 1 percent of gross sales in local R&D or at least 7 percent of the workforce being science and technical graduates. Malaysian firms are eligible for investment tax allowance of 60 percent on qualifying capital expenditure within five years (if these firms are involved in the design, develop, or manufacture the technologies), or granted pioneer status with full tax exemption for five years. In addition, specific incentives for investment in R&D are provided under the Promotion of Investments Act, 1986, which include:

- Companies conducting R&D in Malaysia for their own business can claim an investment tax allowance of 50 percent on the qualifying capital expenditure for up to ten years.
- Companies providing R&D in Malaysia for their own business and for other companies can claim an investment tax allowance of 100 percent on the qualifying capital expenditure for up to ten years.
- Companies providing R&D in Malaysia only to unrelated companies, that is contract research, can claim investment tax allowance of 100 percent on the qualifying capital expenditure for up to ten years, or claim pioneer status for five years with full tax exception at statutory income level (Tidd and Brocklehurst 1999, p. 250).

Malaysian government also launched ambitious Multimedia Super Corridor (MSC) programme in an effort to develop information technology and multimedia sectors. It remains under-researched and impact of MSC programme on the national innovation and R&D capabilities has not been investigated. According to UNESCO (2004) report on R&D expenditure, in Malaysia, total gross domestic expenditure on R&D (GERD) as percentage of GDP has increased at a very low pace, from 0.22 to 0.69 percent over the period of 1996-2002. GERD per capita (measured PPPs), has shown very marginal increase from 16.9 to 64.2. Whereas, in neighboring country, Singapore, GERD per capita (measured PPPs), has increased from 271.5 to 627.3 over the same period. The R&D effort within the total national enterprise shows contribution of 65.3 percent by private business enterprises, 20.3 percent government and 14.4 percent higher educational institutes in Malaysia. The full-time equivalent researchers per million inhabitants have increased from 91 to 299 in Malaysia compared significant increase in Singapore from 2,538 to 4,999 over the same period. Indeed, the importance of R&D staff is also highlighted by Jaumotte and Pain (2005a, b), who found that availability of scientists and engineers matter for innovativeness in a study of 20 OECD countries.

Some writers are critical of Malaysian government achievements so far. There is little prospect of innovation led growth as Tidd and Brocklehurst (1999) report, "Chinese family businesses dominate in most of the sectors in Malaysia and the strength of their businesses lie more in cost cutting and service delivery than innovation". This ownership pattern was comprehensively explained in Claessens *et al.* (2000). They studied 3,000 corporations in the East Asian to track their ultimate ownership in 1996 and reported that family ownership constitutes 67.2 percent in Malaysia. Hanazaki and Liu (2007) examined the impact of the family-ownership in the East Asian countries and further added that family-controlled firms face financial constraints which significantly reduce their investment expenditure, applying these findings to Malaysian case might seem to suggest a Malaysian family-owned firms have lower motivation to increase R&D expenses because there might be other competing investment projects. The corporate sectors see R&D as a cost rather than a long-term investment. The management does not assess the risk and return on R&D and seek alternative ways to achieve productivity growth in the industry such as cost reduction initiatives or business process re-engineering. Although government has targeted "high technology" sector such as electrical, electronics and semiconductors but to date very few large (RM $>$ 100 million) projects have been established. According to Seventh Malaysian Annual Plan (1996-2000), the number of full and part-time researchers and scientists were estimated to be at 8,300. This gives a ratio of 400 per million population which can be considered low compared with the ratios ranging from 1,000 to 1,500 per million population found in some newly industrializing economies, when they were at Malaysia's current level of economic development. Recently, Jaafar *et al.* (2007) report Malaysian contractors' readiness to embrace new technology. They find that surveyed managers were moderate in terms of their technology readiness. Bigger firms are more optimistic compared to smaller firms but with no significant difference in overall readiness.

We draw the landscape of R&D in Malaysia starting at the macro-level and then moving towards the micro-level (firm-level). Table I shows the number of patents granted to various establishments in Malaysia over the period 1991-2006. At first sight, Malaysia seems to be ahead of its Islamic counterpart countries in R&D, but it lags significantly behind Asian countries such as Singapore, South Korea, Taiwan, and Hong Kong. On the other hand, two of the world's populated economies; India and China seem to have a very close competition in R&D spending.

Table II shows that semiconductor product class has the highest number of utility patents in Malaysia. Pharmaceutical, automobile, biotechnology, engineering, and

Class	Class title	2001	2002	2003	2004	2005	Total
438	Semiconductor device manufacturing: process	14	10	5	7	8	44
257	Active solid-state devices (e.g. transistors, solid-state diodes)	1	5	3	9	12	30
324	Electricity: measuring and testing	0	0	1	3	6	10
455	Telecommunications	1	2	2	1	2	8
29	Metal working	2	1	2	2	0	7
361	Electricity: electrical systems and devices	1	1	0	1	4	7
439	Electrical connectors	1	2	2	0	2	7
385	Optical waveguides	1	1	1	1	2	6
606	Surgery (instruments)	0	2	2	1	1	6
5	Beds	0	0	0	5	0	5
264	Plastic and nonmetallic article shaping or treating: processes	0	0	0	5	0	5
607	Surgery: light, thermal, and electrical application	1	2	1	1	0	5
710	Input/output (electrical computers and digital processing systems)	1	0	2	0	2	5
174	Electricity: conductors and insulators	0	0	1	2	1	4
228	Metal fusion bonding	0	1	0	1	2	4
356	Optics: measuring and testing	1	1	2	0	0	4
362	Illumination	0	1	1	0	2	4
365	Static information storage and retrieval	0	0	1	2	1	4
428	Stock material or miscellaneous articles	0	1	0	3	0	4
430	Radiation imagery chemistry: process, composition, or product thereof	1	1	1	0	1	4
520	Synthetic resins or natural rubbers (includes classes 520-528)	1	0	1	1	1	4
52	Static structures (e.g. buildings)	1	0	0	1	1	3
106	Compositions: coating or plastic	0	0	0	1	2	3
134	Cleaning and liquid contact with solids	0	0	1	0	2	3
144	Woodworking	0	0	1	2	0	3
250	Radiant energy	0	0	1	1	1	3
315	Electric lamp and discharge devices: systems	0	0	0	1	2	3
327	Miscellaneous active electrical nonlinear devices, circuits, and systems	0	1	0	0	2	3
340	Communications: electrical	2	0	0	1	0	3
341	Coded data generation or conversion	0	0	0	2	1	3
343	Communications: radio wave antennas	2	0	0	1	0	3
419	Powder metallurgy processes	0	0	1	1	1	3
426	Food or edible material: processes, compositions, and products	1	0	1	1	0	3
33	Geometrical instruments	0	1	0	0	1	2
62	Refrigeration	0	1	0	1	0	2
73	Measuring and testing	0	2	0	0	0	2
108	Horizontally supported planar surfaces	0	1	0	1	0	2
123	Internal-combustion engines	0	0	0	2	0	2
206	Special receptacle or package	0	1	1	0	0	2
242	Winding, tensioning, or guiding	0	0	1	0	1	2
294	Handling: hand and hoist-line implements	0	0	0	1	1	2
312	Supports: cabinet structure	0	0	0	0	2	2
313	Electric lamp and discharge devices	0	0	0	2	0	2

(continued)

Table II.
Patents granted to Malaysia 2001-2005

Class	Class title	2001	2002	2003	2004	2005	Total
320	Electricity: battery or capacitor charging or discharging	0	1	0	1	0	2
331	Oscillators	0	1	0	0	1	2
345	Computer graphics processing and selective visual display systems	0	0	0	1	1	2
347	Incremental printing of symbolic information	0	0	0	0	2	2
359	Optics: systems and elements	0	1	0	0	1	2
363	Electric power conversion systems	2	0	0	0	0	2
372	Coherent light generators	0	2	0	0	0	2
422	Chemical apparatus and process disinfecting, deodorizing, preserving, or sterilizing	0	0	1	0	1	2
424	Drug, bio-affecting and body treating compositions (includes class 514)	0	0	2	0	0	2
429	Chemistry: electrical current producing apparatus, product, and process	0	1	0	1	0	2
433	Dentistry	1	0	1	0	0	2
435	Chemistry: molecular biology and microbiology	0	0	1	0	1	2

Notes: This table reports the number of utility patents granted to Malaysia according to product segment defined by US Patent and Trade Mark Office over the period of 2001-2005. Table excludes those sectors which had only one utility patent over the period of 2001-2005

Table II.

aerospace product classes have even less than ten patents. The firms in "high technology" sector such as semiconductors have the highest growth in the number of patents (Table III). These statistics are not surprising given the fact that special incentives provided to "high-technology" firms in Malaysia. Ahmad and Sulaiman (2000) argue that R&D in microelectronic industry has been due to participation of foreign multinational in Malaysia. For instance, Intel opened a design centre in Penang in 1992 to make new line of microprocessors. They report that only one domestic

Firm name	2001	2002	2003	2004	2005	2006
Agilent Technologies	1	0	2	11	22	36
Chartered Semiconductor Manufacturing Pvt. Ltd	13	8	3	2	1	27
Ceram Optec Industries	3	9	6	3	5	26
Intel Corporation	1	0	5	4	11	21
Motorola	6	6	2	4	1	19
National Semiconductor Corporation	0	2	3	7	5	17
Semiconductor Components Industries, LLC	0	5	1	0	2	8
Grossman Product Services sdn. Bhd.	0	1	1	5	0	7
Advanced Micro Devices	1	0	3	1	1	6
Altera Corporation	0	1	1	1	2	5
Serac Group	0	0	0	3	2	5
Total firm – level patents owned	25	32	27	41	52	177
Individually owned patent	2	9	6	13	6	36

Note: This table shows the firms receiving utility patents defined by US Patent and Trade Mark Office over the period of 2000-2005
Source: Utility patents defined by US Patent and Trade Mark Office

Table III. Patents granted to Malaysian listed firms 2001-2006

Malaysian firm MIMOS Bhd is involved in applied research in information and wireless technologies using industry, universities, and government assistance. We argue that to date no empirical work has been done to capture the determinants and trend of R&D spending in Malaysia, and thus, our analysis constitute a first step in this direction. In the next section, we describe the R&D at micro-level.

4. Sample, variables, and model

4.1 Sample

The sample includes all the non-financial firms listed on the Main Board of Malaysian Stock Exchange for which financial data is available over the period of 2000-2005. We hand-collected the non-financial data such as CEO tenure and CEO work experience information, from the annual reports of the firms and supplemented the data downloaded from Worldscope which resulted in a sample of 142 firms. Since our main interest is in R&D expenses therefore, we included only those firms for which we have information of R&D expenses consecutively. This sample selection criterion is similar to the previous studies such as Gugler (2003) who used a sample of only 137 R&D doing firms out of 214 non-financial firms drawn from the 600 largest non-financials in Austria.

After excluding firms:

- not having continuous data for at least three years over the period of 2000-2005; and
- not having data on CEO stock options, the final number of firms selected for analysis is 38 giving 228 firm-year observations.

It is possible that omitting firms that have not undertaken (or reported) consecutively R&D activity in three years create a sample selection bias towards more stable or large listed firms[1]. We also did separate analysis for those firms not having three years consecutively data on R&D. In order to make sure that these 38 firms represent that the Malaysian stock market as a whole. We compared the stock market capitalization of these firms with total market capitalization. Table IV shows that these firms capture more than one third of the total Main Board market capitalization, and the average market capitalization of these firms, 28.59 percent is higher compared to 20.38 percent for those firms which do not have complete three years data on the R&D expenses.

4.2 Variables

The empirical objective of this paper is to examine the determinants of firm-level R&D spending in Malaysia. We use variables, R&D expenditure over sales and R&D expenditure per employee as a proxy for R&D intensity, as in previous research (Barker and Mueller, 2002). The literature on the determinants of R&D has identified several variables related to manager/owner characteristics and firm specific characteristics. Among the manager/owner related variables, entrenchment of the managers/directors has come to forefront of investigation. According to the agency costs literature (Jensen and Meckling, 1976; Jensen and Murphy, 1990), stock options is a useful way to encourage managers' risk taking behavior to align with the interests of shareholders. Stock option ownership will have affect on the R&D expense of the firm because when firms invest in R&D activities to improve production and lower operation costs this leads to increase in share performance. Thus, managers with high stock options would be more inclined to take risky R&D activities. We define a variable SOPTION that is the

Year	Sample firms	Firms with incomplete R&D data	All firms
2000	14.96	10.81	25.77
2001	20.44	14.66	35.10
2002	29.28	18.48	47.76
2003	32.67	24.88	57.55
2004	35.92	26.55	62.47
2005	38.32	26.95	65.27
Mean	28.59	20.38	49.98
Max.	38.32	26.95	65.27
Min.	14.96	10.81	25.77
N	38	120	142

Notes: This table reports the sample firms' market capitalization to Malaysian Main Board total stock market capitalization (in percentage) over the time period of 2000-2005. The table also compares the sample firms' market capitalization ratio as defined, to market capitalization of those firms which have incomplete data on R&D for consecutive three years and all firms for which data were downloaded from database. The data on the market value of the firms in the sample were collected from Worldscope database from 2000 to 2005

Table IV. Representativeness of sample firms

average value of stock options granted in each year to the CEO of a firm. As Murphy (1999) points out, CEO options are vested over time and it is possible that only 25 percent are used in each of the following four years after the grant. To control for the lagged effect of stock options, we use the average value of stock options over the preceding two years. Wu and Tu (2006) suggest that effect of CEO stock option pay on R&D spending is contingent upon the extent to which a firm's slack resources can buffer managerial decisions from downside risks; therefore, we use a variable SLACK that is the ratio of selling, general, and administrative expenses to sales. We include other variables related to CEO characteristics, such as TENURE, i.e. the number of years a CEO has been appointed; and EXPR equal to 1 if CEO has experience in marketing, engineering/R&D otherwise 0, followingBarker and Mueller (2002).

We use the information on the hiring and training costs, and the number of staff involved in R&D as our measure of R&DCAPACITY building measures. Among the firm-specific characteristics, we include firm's sales growth from year $t-1$ to t (SG), diversification total number of active subsidiaries (SUBDRY); total sales to average total assets (ATO); total cash flow to sales ratio (CF), and ratio of total debt to total assets (DEBT). To test the impact of tax incentives, we set up a dummy variable TEXP equal to 1 if a firm is exempted from tax under any government scheme (Section 3) otherwise zero. We obtained the information about the tax exemption status of the firms from the annual reports.

We should expect the leverage to have a negative effect on R&D spending as Blundell *et al.* (1999) point out that external sources of finance may be more expensive and there is the risk that rival firm could acquire valuable information if a firm seems external funding for its innovation projects. The effect of tax exemption on the firm-level R&D is also expected to be positive.

4.3 Descriptive statistics

The descriptive statistics show that, RDS is relatively lower than RDE (Table V, panel A). The mean (median) CEO TENURE is 12 years (14 years); mean (median) ATO is 0.81

Table V.
Descriptive statistics

Panel A: descriptive statistics

	Mean	*Median*	*Std*	*Max.*	*Min.*
TRAING (in Mill)	4.40	3.70	4.70	9.9	0.1
RDS	0.01	0.00	0.01	0.2	0.0
RDE	2.40	0.30	6.5	5. 5	0.01
SOPTION (in log)	5.30	1.10	4.0	12.1	2.0
TENURE (years)	12.8	14.0	6.60	22.0	1.00
SG	0.10	0.10	0.40	2.9	−0.84
SLACK	0.10	0.10	0.2	1.9	0.00
SUBDRY	29.3	16.0	35.8	120.0	1.00
ATO	0.80	0.70	0.60	60.6	0.00
CF	0.10	0.02	0.30	1.9	−1.32
DEBT	18.60	6.60	19.6	60.7	0.00

Panel B: correlation

	RDS	*RDE*	*SG*	*TENURE*	*SLACK*	*SUBDRY*	*ATO*	*CF*
RDS	1.00							
RDE	0.76*	1.00						
SG	0.02	−0.02	1.00					
TENURE	0.02	0.31	−0.54	1.00				
SLACK	0.16*	0.04	−0.17	0.39	1.00			
SUBDRY	−0.17	−0.16	0.03	0.51	0.33*	1.00		
ATO	−0.09	0.11	0.04	0.29	−0.19*	−0.16	1.00	
CF	0.24*	0.13**	−0.06	−0.21	0.07	−0.14	−0.096	1.00

Notes: Significant at the *1, **5 and ***10 percent levels, respetively. This table shows the descriptive statistics and correlation coefficients of the variables used in analysis over the period of 2000-2005. All the firm-level data were hand-collected and supplemented with data from Worldscope. RDS is total R&D expenditure divided by total sales; RDE is total research and expenditure divided by total number of employees; SOPTION is log of the value of stock options granted in each year to the CEO of a firm; TRAING is the total training cost. TENURE is the number of years a CEO has been in position; SLACK is the ratio of selling, general, and administrative expenses to sales; SG firm's growth opportunities; SUBDRY is number of subsidiaries of a firm; ATO is the total Assets turnover ratio defined as the ratio of total sales to average total assets; CF is total cash flow to sales ratio; DEBT is ratio of total debt to total assets ratio

(0.70); and mean (median) CF is 0.10 (0.02). Taken together, these statistics suggests that on average a CEO remains quite entrenched in Malaysian firms. It seems that one of the source of entrenchment might be the absence of any large outside shareholders who have the capability to offset the influence of inefficient managers who might choose to use the ESOP to further entrench themselves into their positions. Thus, it becomes more interesting to know what has been the impact of this entrenchment on the R&D of firms in Malaysia.

The correlation coefficients show that, there is significant positive correlation between two measures of R&D intensity (Table V, panel B). Furthermore, significant positive correlation between both measures of R&D intensity and CF, suggest that firm spending increases as positive cash flows become available. There is a significant positive correlation between SLACK and RDS suggesting that absorbed slack affect R&D. Our findings are similar to Wu and Tu (2006) in that, they report a significant positive correlation between absorbed slack and R&D spending as well as CEO stock option and R&D spending.

4.4 Persistence in research and development spending

In this section, we examine the persistence in firms' R&D spending. The transition of firms from lower to higher level of R&D expenses (defined as the ratio of R&D expenses to total sales) provide much clear picture on the innovative characteristics of the firms. This section reports on the changes, from one period to another, in the average R&D spending of the firms. We first calculated the average R&D spending of firms over the two time periods: 2001-2003 and 2004-2006. We computed the percentiles of the average R&D and then placed firms into one of the ten categories (Table VI). Elements in diagonal in the table reflects the persistence of the firm spending that is a firm remains in the same percentile of the spending, from one period to another period. On the other hand, movement away from the diagonal shows the changes in spending level, respectively.

Table V shows that most of the firms are concentrated in the upper left quadrants. Firms have a greater tendency to maintain their spending level (i.e. 14 out of 38 firms maintained their spending level, whereas, only ten firms increased their R&D spending over the sample period). Panel B of the table shows that, almost 23 percent of the R&D spending increases are between 50 and 100 percent, whereas 38 percent of the R&D spending cuts are between 50 and 100 percent over the entire sample period, which seems to suggest that a large number of firms tend to decrease R&D spending.

4.5 Estimation model

We investigate the determinants of the R&D expenses of the Malaysian firms by estimating an R&D expenditure function. In particular, we are interested in the extent to which managers' and firms' specific characteristics affect firm-level R&D expenses. Our model is line with Ogawa (2007) who used a R&D investment specification. Unlike Ogawa (2007) who estimated both a fixed- and random-effect model, we used panel least square method because unobserved firm specific effect are directly captured by explanatory variables such as such as TENURE, i.e. the number of years a CEO has been appointed; and EXPR equal to 1 if CEO has experience in marketing, engineering/R&D otherwise 0, following Barker and Mueller (2002). The panel regression model is:

$$\begin{aligned}\mathrm{RD}_{i,t} = \alpha + \beta_1\mathrm{CF}_{i,t-1} + \beta_2\mathrm{SG}_{i,t-1} + \beta_3\mathrm{SLACK}_{i,t-1} + \beta_4\mathrm{ATO}_{i,t-1} \\ + \beta_5\mathrm{DEBT}_{i,t-1} + \beta_6\mathrm{SUBDRY}_{i,t-1} + \beta_7\mathrm{SOPTION}_{i,t} + \beta_8\mathrm{TEXP}_{i,t} \\ + \beta_9\mathrm{TENURE}_{i,t} + \beta_{10}\mathrm{EXPR}_{i,t} + \varepsilon_{i,t},\end{aligned} \quad (1)$$

where the dependent variable is R&D expenses divided by total employees of a firm in year t. CF is the ratio of cash flows to sales; SG is the growth in total sales from year $t-1$ to yea t; SLACK is the ratio of selling and administrative expenses to total sales; ATO, is total sales to average total assets; DEBT is the total debt to assets ratio; SUBDRY is the number of subsidiaries owned by a firm; SOPTION is the average value of the stock options granted to CEO of a firm in year t; TEXP is a dummy variable equal to 1 if a firm has been exempted from tax payment under any government scheme; TENURE is the number of years for which a manager has been appointed as a CEO; EXPR is a dummy variable equal to 1 if a CEO has prior experience in the research and marketing otherwise 0.

We are mindful of the potential problem of multi-collinearity among variables in our regression model in equation (1), however VIF test indicate no significant problem exist

Table VI.
Transition matrix and distribution of changes in the R&D spending

Panel A: transition matrix

						2004-2006						
		1	2	3	4	5	6	7	8	9	10	Total
2001-2003	1	*2*	0	0	0	1	0	0	0	0	0	3
	2	1	*2*	0	1	0	0	0	0	0	0	4
	3	2	0	*2*	0	0	0	0	0	0	0	4
	4	1	1	1	*0*	1	0	0	0	0	0	4
	5	0	0	0	3	*1*	0	0	0	0	0	4
	6	0	0	1	0	0	*2*	1	0	0	0	4
	7	1	0	0	0	0	0	*1*	1	1	0	4
	8	0	0	0	0	0	0	0	*1*	1	2	4
	9	0	0	0	1	0	1	0	0	*1*	1	4
	10	0	1	0	0	0	0	0	0	0	*2*	3
	Total	7	4	4	5	3	3	2	2	3	5	38

Panel B: distribution of changes in the R&D spending

Range of changes in spending on R&D (%)	*Increase*	*Total increases (%)*	*Decreases (cuts)*	*Total decreases (cuts) (%)*
0 < 10	6	27	2	11
10- < 20	5	23	–	–
25-50	6	27	8	50
50-100	5	23	6	38
Total	22		16	

Notes: This table shows the number of firms, in italics, moving across percentiles of average spending on R&D from period 2001-2003 to 2004-2006 in panel A. The data on R&D were obtained from Worldscope over the sample period of 2000-2006. The range of changes in the R&D spending is shown in panel B in our model. We are also mindful of the fact that there might be dynamic feedback effects, which cannot be ignored such as reverse causality: firms who innovate will grow and therefore have higher sales volume (Blundell *et al.*, 1999). The estimation results are shown by using explanatory variables in four different specification of the regression model in Table VII.

5. Results and discussion

Before we present the results, it is important to highlight that our model passes the specification and diagnostic tests of no serial correlation, and non-normality of the residuals. The regression results reported in Table VI shows that SLACK and SG have significant positive influence on the current R&D spending of the firms (see column a). In this regard, our findings are similar to Ogawa (2007) who also found that rate of output growth of Japanese firms had a positive effect on R&D investment during the period 1999-2001. The coefficient on the SLACK is the higher compared to SG variable. This finding implies that absorbed slack plays a significant role. The slack variables are related to the free cash flows available to the firm. Thus, the finding of their significance could also be compared to the findings in Hanazaki and Liu (2007) on investment problems in general.

We find that DEBT variable is insignificant in our estimation result which is in contrast to the recent findings of the Ogawa (2007). This result seems to suggest that availability of the private external finance such as the bank loans are not crucial for the Malaysian firms' R&D investment which may be because of their access to stock and bond markets. There might be other reasons for such a result. First, it can be conjectured that Malaysian firms in our sample might be export-oriented and might have access to international capital markets. Previous studies (Bae and Noh, 2001; Bhagat and Welch, 1995) report that firms operating in international markets have lower debt ratios. Second, Myers (1977) argue that when firms face possible financial distress, it is suboptimal for firms involved in R&D activities to also carry a high debt ratio, because such debt would carry prohibitive costs and/or covenants.

On the other hand, significant negative coefficient on the SUBSDRY seems to suggest that unplanned low growth diversification into new areas might have reduced R&D spending. This result requires a cautious interpretation because it might be possible that some of the sample firms were affected by downward performance of their subsidiaries following, which might have mandated revision in the R&D spending. There is also a negative coefficient on TEXP variable.

We do not find any significant effect of SOPTION, TENURE, and EXPR experience in marketing/R&D on the R&D spending after controlling for the effect of other firm-specific factors (see column c). This result is opposite to the findings of Chen and Huang (2006) who found a significant positive relationship between employee stock options and R&D investment in Taiwan in information technology industries over the sample period of 1996-2001. Taiwan has the highest number of patents (Table I) and also it has been quoted by various industry leaders as a country, where distributing a certain percentage of stock can motivate employees which positively influenced the information technology development (Chen and Huang, 2006, p. 371). One possible explanation for our finding might be uncertainty regarding the payoffs from the R&D investment might increase managerial concern for personal wealth and job security; therefore, risk averse managers may be less likely to make R&D expenditures

Table VII.
The estimation results of the regression model

	a	b	c	d	e
CONSTANT	0.3592 (0.2841)	1.0833* (0.2979)	0.7246 (0.3961)	1.3056* (0.3043)	4.9112* (0.7421)
SLACK	4.6386** (2.5077)	–	3.6007 (2.6060)	0.6007* (0.1060)	0.0929* (0.3034)
SG	0.6566** (0.3227)	–	0.3381 (0.4275)	0.2539 (0.3499)	−1.5180 (1.0621)
DEBT	−0.0407 (0.0417)	–	−0.0562 (0.0554)	0.0444 (0.0746)	0.0916** (0.0425)
SUBDRY	−0.0784* (0.0335)	−0.0574** (0.0264)	−0.0866 (0.0342)	−0.0420 (0.0291)	−0.0541** (0.0200)
TEXP	−0.5297*** (0.3127)	−0.0721 (0.2455)	−0.4314 (0.3558)	−0.1996 (0.4698)	−0.6838 (0.7552)
CF	–	−7.1892** (3.2097)	−5.5550 (4.2191)	−1.7270 (6.1457)	0.4653 (0.3123)
ATO	–	−0.0221 (0.2849)	−0.0119 (0.3303)	−1.4277*** (0.5899)	0.0788** (0.0525)
SOPTION	–	–	−0.3034 (0.2334)	−0.3140 (0.2869)	−0.1100 (0.2079)
TENURE	–	–	0.6002 (0.5722)	0.5003 (0.4313)	0.5014 (1.0121)
EXPR	–	–	0.0451 (0.0386)	0.0357 (0.0390)	0.0017 (0.1070)
SIC3 (engineering)	–	–	–	0.8406*** (0.4778)	0.5223* (0.2322)
SIC4 (manufacturing)	–	–	–	0.5835** (0.2798)	0.8516* (0.4051)
SIC5 (plantation)	–	–	–	2.4056 (0.7491)	1.7991 (1.2993)
SIC6 (pharmaceutical)	–	–	–	2.4056* (0.7419)	3.0854* (0.9950)
DW	1.1808	1.2475	1.3414	2.0736	1.7543
Adj. R^2	5.86%	6.65%	6.43%	47.02%	45.58%
JB	1.5481	1.1517	1.8259	1.9050	1.2280
RESET	0.8720	0.1316	0.0200	3.3277	4.4720
No. of firms	38	38	38	38	120

Notes: Significant at the *1, **5 and ***10 percent levels, respectively. Panel regression model is explained in equation (1). SIC3-SIC6 are industry dummies. DW is Durbin Watson test for testing serial correlation in residuals of the regression model. JB is a Jarque-Berra test for testing normality of the residuals, and RESET is Ramsey specification test. The standard errors are robust and White Heteroskedasticity corrected

(Wiseman and Gomez, 1998). The absence of any significant effect of these managerial entrenchment variables on the level of R&D spending at firm-level is a new finding in the Malaysian context, and it seems to suggest that factors other managerial entrenchment are at work.

In our final specification (*d*), we included industry dummy variables to capture the impact of industry environment on the R&D spending. The industry variables are significant suggesting that industry environment also have significant influence on the R&D expenses of an average firm in Malaysia. We observe no significant effect of tax exemption, which seems to support the result of previous study (Tidd and Brocklehurst, 1999) that the impact of tax exemptions has been less than impressive. Indeed some economists argue that the absolute tax price elasticity of R&D is low (Bloom *et al.*, 2002).

In order to examine further whether our estimation results are not sample specific, we estimated our model in equation (1) for all the sample firms relaxing the criteria that the firms should have at least three years of observations (Table VII, column e). The variables such as SLACK, and industry variables are all significant as before, however, we find that DEBT and SUBSDRY are now positive and negative signs, respectively. It seems that our restricted sample may have consisted of those firms which rely less on debt compared to unrestricted sample. Once again, we do not find any significant coefficient on the managerial entrenchment variables such as SOPTION, TENURE, and EXPR, respectively. Demsetz and Lehn (1985) report that managerial ownership level is driven by a variety of firm and industry characteristics, thus, once we controlled for industry and firm effect, may be the importance of these variables have declined in our estimation.

6. Conclusion

In this paper, we examined the Malaysian firms' spending on the R&D. Our findings shows that the Malaysian firms increase R&D spending due to future investment opportunities observed through increase in output or sales growth. We do not find any significant effect of CEO characteristics on the R&D expenses of the firms. We do not find any significant effect of any government tax exemption scheme on the R&D expenses of the firms suggesting that these firms might have qualified for exemption but did not appear to be investing at high level in the innovation activities.

There are obvious limitations to our work, some of which preclude us from making sweeping generalizations about the state of R&D spending in Malaysia. First, the number of sample firms could be further extended by using other proprietory databases if available. Second, disclosure of the stock options data in the annual report was sparse in the early years of the sample period. We hope to take into account other factors not included in this work, such as impact of demand conditions in the industry, other macro-economic factors and firm specific factors in a behavioral model setting in our future work. Managerial ownership instead of stock options might provide us better link between managerial ownership and firm-level innovation. Also we are mindful of the fact that further dis-aggregated data at the plant-level might be useful to examine to tax-price elasticity of R&D spending.

Our work has important corporate governance implications in that managers should invest according to the corporate innovation charter (if any) to avoid strategic drift into low growth diversification. We suggest that the corporate governance charter of the firm should include monitoring of R&D spending by board of directors to provide shareholder a better view of the firm's competitiveness in the industry. To support a board member's effort to pursue this deeper level of involvement, the board as a whole must be willing to engage in strategic planning that will set the future direction for a firm. The board members must be able to engage lower level employees and supervisors to produce significant process led innovations that will establish the competitive advantage in the marketplace. At present most of the boards in Malaysia are packed with either old or re-appointed non-independent directors, there is also need to hire capable, experienced and qualified young directors from the various ethnic groups in the country. Although the revised Malaysian Corporate Governance Code (2007) requires that all directors should submit themselves for re-election at regular intervals and at least three years, but it is seen that re-election of directors ends in selecting old directors due to loyalty with the firms. There is also a need for director's training and education programme for new recruits on board.

Note

1. An alternative approach that could have been used is Heckman (1979) sample selection model; we are thankful to anonymous referee for this suggestion.

References

Ahmad, I.B. and Sulaiman, N.B. (2000), "Microelectronic industry in Malaysia", *International Conference on Software Engineering Proceedings*, *Guoman Port Dickson Resort, Malaysia*, pp. 134-8.

Bae, S.C. and Noh, S. (2001), "Multinational corporations versus domestic corporations: a comparative study of R&D investment activities", *Journal of Multinational Financial Management*, Vol. 11, pp. 89-104.

Barker, V.L. and Mueller, G.C. (2002), "CEO characteristics and firm R&D spending", *Management Science*, Vol. 48, pp. 782-801.

Bhagat, S. and Welch, I. (1995), "Corporate research and development investments international comparisons", *Journal of Accounting and Economics*, Vol. 19, pp. 443-70.

Bloom, N., Griffith, R. and Reenen, V.J. (2002), "Do R&D tax credits work? Evidence from a panel of countries 1970-1997", *Journal of Public Economics*, Vol. 85, pp. 1-31.

Blundell, R., Griffith, R. and Reenen, V.J. (1999), "Market share, market value, and innovation in a panel of British manufacturing firms", *Review of Economic Studies*, Vol. 66, pp. 529-54.

Chen, H.L. and Huang, Y.-S. (2006), "Employee stock option ownership and corporate R&D expenditures: evidence from Taiwan's information technology industry", *Asia Pacific Journal of Management*, Vol. 23, pp. 369-84.

Claessens, S., Djankov, S. and Lang, L. (2000), "The separation of ownership and control in East Asia", *Journal of Financial Economics*, Vol. 58, pp. 81-112.

Demsetz, H. and Lehn, K. (1985), "The structure of corporate ownership: causes and consequences", *The Journal of Political Economy*, Vol. 93 No. 6, pp. 1155-77.

Economic Planning Unit (1996), *Seventh Malaysia Plan 1996-2000*, Economic Planning Unit, Prime Minister's Department, Kuala Lumpur.

Ernst, H. (1998), "Industrial research as a source of important patents", *Research Policy*, Vol. 27 No. 1, pp. 1-15.

Global R&D Report (2005), *Global R&D Report*, available at: www.rdmag.com

Gugler, K. (2003), "Corporate governance, dividend payout policy, and the interrelation between dividends, R&D, and capital investment", *Journal of Banking & Finance*, Vol. 27 No. 7, pp. 1297-321.

Hanazaki, M. and Liu, Q. (2007), "Corporate governance and investment in east Asian firms – empirical analysis of family controlled firms", *Journal of Asian Economics*, Vol. 18, pp. 76-97.

Heckman, J.J. (1979), "Sample selection bias as a specification error", *Econometrica*, Vol. 47, pp. 153-61.

Hershberg, E., Nabeshima, K. and Yusuf, S. (2007), "Opening the ivory tower to business: university-industry linkages and the development of knowledge-intensive clusters in Asian cities", *World Development*, Vol. 35 No. 6, pp. 931-40.

Hu, M.-C. and Mathews, J. (2005), "National innovative capacity in East Asia", *Research Policy*, Vol. 34 No. 9, pp. 1322-49.

Jaafar, M., Aziz, A., R, A.A., Ramayah, T. and Saad, B. (2007), "Integrating information technology in the construction industry: technology readiness assessment of Malaysian contractors", *International Journal of Project Management*, Vol. 25 No. 2, pp. 115-20.

Jaumotte, F. and Pain, N. (2005a), "An overview of pubic policies to support innovation", Working Paper No. 456, OECD Economics Department, Paris.

Jaumotte, F. and Pain, N. (2005b), "From ideas to development: the determinants of R&D and patenting", Working Paper No. 457, OECD Economic Department, Paris.

Jensen, M.C. and Meckling, W.H. (1976), "Theory of the firm: managerial behavior, agency costs and ownership structure", *Journal of Financial Economics*, Vol. 3, pp. 305-60.

Jensen, M.C. and Murphy, K.J. (1990), "CEO incentives: it's not how much you pay, but how", *Harvard Business Review*, Vol. 68, pp. 138-53.

Malaysian Corporate Governance Code (2007), *Amended Corporate Governance Code*, Bursa Malaysia, Kuala Lumpur.

Murphy, K.J. (1999), "Executive compensation", in Ashenfelter, O. and Card, D. (Eds), *Handbook of Labor Economics*, North Holland, Amsterdam, pp. 2485-563.

Myers, S.C. (1977), "Determinants of corporate borrowing", *Journal of Financial Economics*, Vol. 5 No. 2, pp. 147-75.

Ogawa, K. (2007), "Debt, R&D, investment and technological process: a panel study of Japanese manufacturing firms' behavior during the 1990s", *Journal of the Japanese and International Economies*, Vol. 21, pp. 403-23.

Sohn, D.-W. and Kenney, M. (2007), "Universities, clusters, and innovation systems: the case of Seoul, Korea", *World Development*, Vol. 35 No. 6, pp. 991-1004.

Tidd, J. and Brocklehurst, M. (1999), "Routes to technological learning and development: an assessment of Malaysia's innovation policy and performance", *Technological Forecasting and Social Change*, Vol. 62, pp. 239-57.

Tidd, J., Bessant, J. and Pavitt, K. (2001), *Managing Innovation: Integrating Technological, Market and Organizational Change*, Wiley, Chichester.

UNESCO (2004), "A decade of investment in research & development (R&D): 1990-2000", *UIS Bulletin on Science and Technology Statistics*, Vol. 1, pp. 1-4.

Upstill, G. and Hall, P. (2006), "Innovation in the minerals industry: Australia in a global context", *Research Policy*, Vol. 31 No. 3, pp. 137-45.

Wiseman, R. and Gomez-Mejia, L.R. (1998), "A behavioral agency model of managerial risk taking", *Academy of Management Journal*, Vol. 23, pp. 133-53.

Wong, P.-K., Ho, Y.-P. and Singh, A. (2007), "Toward an "Entrepreneurial University" model to support knowledge-based economic development: the case of the National University of Singapore", *World Development*, Vol. 35 No. 6, pp. 941-58.

Wu, J. and Tu, R. (2006), "CEO stock option pay and R&D spending: a behavioral agency explanation", *Journal of Business Research*, Vol. 60 No. 5, pp. 482-92.

Further reading

Greve, H.R. (2003), "A behavioral theory of R&D expenditures and innovations: evidence from shipbuilding", *Academy of Management Journal*, Vol. 46, pp. 685-702.

Kim, S.H. (1987), "Growing and mature stage technology selection patterns of small sized firms in selected Asian countries – Korea, Hong Kong, and Japan", *Technovation*, Vol. 7 No. 1, pp. 63-78.

Mohamed, M.Z. (1995), "Innovation implementations in Malaysian firms: process, problems, critical success factors and working climate", *Technovation*, Vol. 15 No. 6, pp. 375-85.

Rosenberg, N. (1996), "Uncertainty and technological change", in Landau, R., Taylor, R. and Wright, G. (Eds), *The Mosaic of Economic Growth*, Stanford University Press, Stanford, CA.

Sanders, W.G. (2001), "Behavioral responses of CEOs to stock ownership and stock option pay", *Academy of Management Journal*, Vol. 44, pp. 477-92.

Timmer, M.P. (2003), "Technological development and rates of return to investment in a catching-up economy: the case of South Korea", *Structural Change and Economic Dynamics*, Vol. 14 No. 4, pp. 405-25.

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